Regional Analyses of Restoration Planning

PART 3 – GULF OF MEXICO

ESTUARIES OF THE GULF OF MEXICO

The Gulf of Mexico region is defined here as the Gulf coasts of Texas, Louisiana, Mississippi, Alabama and Florida, excluding the Everglades, the Florida Keys, and Florida Bay, which are included in the Southeast Atlantic Regional Summary.

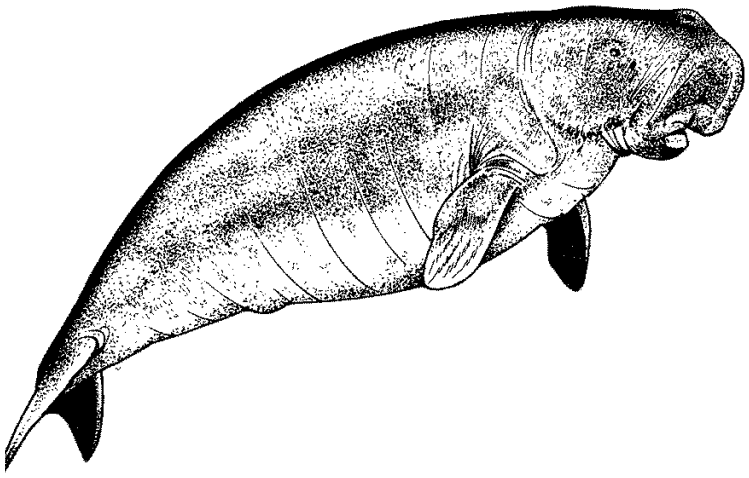
This region:

- Contains the greatest amount of coastal wetlands of any region (NOAA, 1990).
- Drains an area approximately 1.6 million square miles wide, which is equivalent to about 60 percent of the land area of the continental U.S. (Beck et al., 2000).
- Accounts for more than 96,000 square miles of estuarine drainage along the Gulf Coast (NOAA 1990).

These estuaries support more than half the nation's wetlands, as well as communities such as Corpus Christi, Houston, New Orleans, Mobile and Tampa (NOAA, 1990).

SUMMARY

In terms of population, the Gulf Coast is one of the fastest growing regions in the country. This region also supports one of the most productive fisheries in the world. Several excellent programs and plans have been developed for restoration of the Gulf Coast. The Gulf of Mexico Program provides an example of the effective use of partnerships in restoration efforts. This program is the result of a partnership of 18 federal agencies, state agencies from the five Gulf states, and diverse public and private organizations. The Coast 2050 plan is a strategic plan for the survival of Louisiana's coast and coastal communities and promotes restoration and protection on a coast-wide basis. The plan involves federal, state and local entities as well as landowners, environmentalists and scientists. This plan builds on previous restoration planning efforts including the Louisiana Coastal Wetlands Restoration Plan and the Coastal Wetlands Conservation and Restoration Plan. Information needs for the Gulf pertain to gaining a more complete understanding of habitat functions and links between habitats. Nonstructural or "soft" shoreline stabilization is being successfully used in restoration projects throughout the Gulf Coast to battle subsidence and erosion. These methods include coastal dune revegetation or beach nourishment, brush fences and breakwaters, rebuilding of coastal ridges, marsh terracing, dredged material use, and large scale freshwater and sediment diversion.



Introduction to the Gulf of Mexico

Description

For this discussion, the Gulf of Mexico region is defined as the Gulf coasts of Texas, Louisiana, Mississippi, Alabama and Florida, excluding the Everglades, the Florida Keys and Florida Bay.

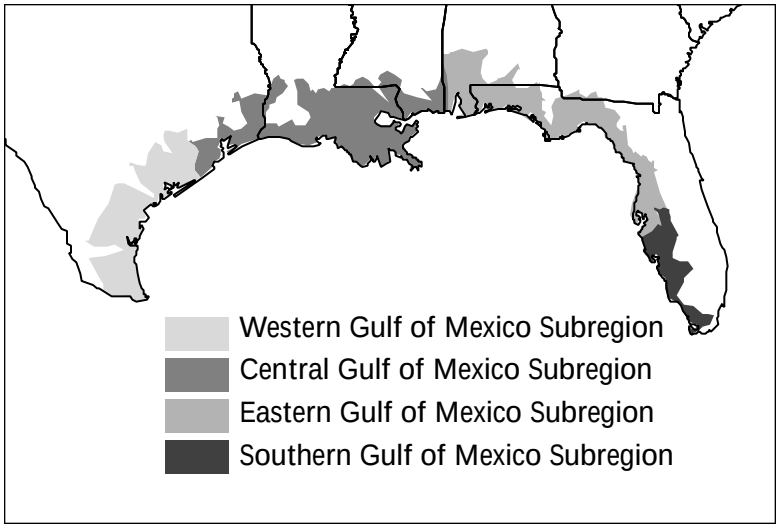


Figure 1: Gulf of Mexico Region and Subregions

The 31 estuarine systems within the Gulf of Mexico region cover approximately 12,000 square miles—accounting for more water surface area than any other region of the United States (NOAA, 1990). The drainage basin for the Gulf of Mexico, which includes the area drained by the Mississippi River, is approximately 1.6 million square miles or 60 percent of the land area of the continental United States (Beck et al., 2000).

Key Habitats and Species

The physical and hydrological conditions within Gulf estuaries are ideal for the formation and growth of wetlands. In fact, the Gulf region contains approximately five million acres of emergent salt marsh and mangrove vegetation, accounting for more than half of the nationwide total (USEPA, 1999). Gulf Coast estuaries also support oyster reefs, submerged aquatic vegetation, tidal flats, open water habitat, barrier islands, swamps, bogs, prairies and forests.

All estuarine habitats within the Gulf of Mexico are designated as essential fish habitat for species managed by the Gulf of Mexico Fishery Management Council, including shrimp, red drum, reef fish, mackerel, stone crab, spiny lobster and coral. The Council defines estuarine habitat as all waters and substrates within estuarine boundaries, including subtidal vegetation. Estuarine boundaries are set landward at the limit of permanent freshwater bottom, and seaward at the coastal barrier islands or other lines of demarcation (NOAA, 1998).

Estuaries and their associated habitats are highly productive and contribute significantly to the ecology of the Gulf of Mexico region. Marshes, mangroves, and seagrass beds provide food and shelter to resident and transient species and function as vital nursery habitats. Gulf Coastal wetlands and barrier islands provide habitat for waterfowl, neotropical migrant birds, shore birds, wading birds, and raptors, as well as a variety of reptiles and mammals. The estuaries of the Gulf Coast also are home to a diversity of protected species, including Kemp's ridley sea turtles, piping plover, brown pelican, West Indian manatee, diamondback terrapin, Texas pipefish and bald eagle.

Habitat-Dependent Activities

Gulf Coast estuaries are centers of residential, recreational, commercial, agricultural and industrial activity. Indeed, estuaries have historically been preferred as centers of human settlement because of the abundance of fish and shellfish, proximity to freshwater and the ocean, and access to inland areas. Today, the estuaries of the Gulf Coast support cities such as Corpus Christi and Houston, Texas; New Orleans, La.; Mobile, Ala.; and Tampa, Fla. The Gulf Coast has one of the fastest growing populations in the country. In 1990 it was estimated that the population of the Gulf region would increase approximately 26 percent by 2010 (NOAA, 1990). Tourism in the Gulf states is valued at $20 billion each year, as beachgoers, boaters, anglers, bird watchers and hunters participate in diverse habitat-dependent activities (USEPA, 1999).

The Gulf Coast supports one of the most productive fishery areas in the world (NOAA, 1990). Commercial finfish and shellfish landings rank first in the nation in both quantity and value, contributing approximately 69 percent of the U.S. shrimp harvest and 57 percent of U.S. oyster production (USEPA, 1999). Commercial and recreational fisheries, which play such a large role in Gulf economies, rely on the health of estuarine habitats. Approximately 95 percent of Gulf Coast landings depend on estuaries during some stage of their life cycle (USEPA, 1999), and studies have demonstrated a quantitative link between wetlands loss and fisheries production (Turner and Boesch, 1988; Turner, 1977).

In addition to recreational uses and commercial fishing, the economies of the Gulf Coast are linked to estuaries in a number of other ways. Estuarine habitats serve as buffers for human communities by improving water quality, protecting shorelines from erosion, and reducing the effects of flooding. The shipping access provided by estuaries of the Gulf supports a great deal of maritime commerce. In terms of total tonnage, seven of

the 10 busiest ports in the United States are in the Gulf region (USEPA, 1999). Of the ships using these ports, approximately 98 percent use the Gulf Intracoastal Waterway (USEPA, 1999). Oil, gas and chemical production and development are prevalent along the Gulf Coast. Approximately 31 percent of the land in the Gulf region is used for agriculture. Silviculture and aquaculture also are significant activities in this region (USEPA, 1999).

These diverse activities affect both the structure and function of the estuarine resources on which they depend. Estuaries have been described as the most anthropogenically degraded habitat type on earth (Edgar et al., 1999). Throughout the Gulf region, estuaries have been altered by many of the factors that affect estuaries worldwide. As Gulf Coast populations increase, the demand for, and impacts on, estuarine resources can be expected to increase as well.

Habitat Status and Trends

Throughout the Gulf region, estuaries and their associated habitats have been altered due to discharge of industrial pollutants and urban waste; alteration of freshwater inflows; dredging of ship channels and oil and gas canals; filling of wetlands; armoring of shorelines; introduction of exotic species; deforestation; application of fertilizers and pesticides; and severing of migratory pathways.

Efforts have been made to assess the current extent of various estuarine habitats and the need for restoration. A 1990 study conducted by the National Oceanic and Atmospheric Administration (NOAA) examined the extent and distribution of marshes (fresh, brackish and salt), estuary scrub-shrub (mangroves) and freshwater forested scrub-shrub wetlands through the use of photos and U.S. Fish and Wildlife Service (USFWS) National Wetland Inventory maps from 1972 and 1984. The total acreage was reported at approximately 3.3 million acres. National trends, however, suggest that wetland coverage has continued to decline since those photos and maps were produced (Freyer et al., 1983). No current studies summarize coastal wetland loss rates for the Gulf as a whole. Information is available from key Gulf Coast estuaries, however, and is discussed for each of the Gulf subregions.

Seagrasses have declined markedly since the 1950s, with most estuaries losing between 20 percent to 100 percent of their seagrass habitat (Handley, 1995). This is mostly the result of water quality degradation from increasing human impacts (Neckles, 1993). Six species of seagrass occur in the Gulf region, accounting for a total of approximately 2.5 million acres (Duke and Kruczynski, 1992).

Water quality within Gulf estuaries is a key issue. More than half of the oyster-producing areas in the region are closed, either permanently or conditionally. There also have been significant changes in both the quantity and timing of freshwater entering the estuaries.

Regional Planning Efforts

The regional nature of the issues faced by Gulf estuaries, coupled with the importance of the resources to the nation, has made the restoration of Gulf habitats a key objective noted in federal and regional plans reviewed. Regional efforts include the Gulf of Mexico Program, The Nature Conservancy's *Ecoregional Plan for the Northern Gulf of Mexico*, and the *Essential Fish Habitat Amendments* prepared by the Gulf of Mexico Fishery Management Council.

The Gulf of Mexico Program is a partnership of 18 federal agencies, state agencies from the five Gulf states, and diverse public and private organizations. The program implements research, demonstration projects, restoration activities and public information activities that focus on restoring seagrass and wetland habitat, enhancing water quality, controlling invasive species, monitoring habitats and educating the public. In the five Gulf states, 12 priority coastal areas have been identified: Corpus Christi Bay, Galveston Bay, Barataria-Terrebonne, Lake Ponchartrain, Mississippi Sound, Mississippi's coastal basins, Mobile Bay, Pensacola Bay, Suwanee River, Tampa Bay, Sarasota Bay and Charlotte Harbor.

The Nature Conservancy's *Ecoregional Plan for the Northern Gulf of Mexico* identifies a collection of sites that, if conserved, managed or restored, could represent the biodiversity of the region, including its nearshore waters. The ecoregional planning process used a reserve selection algorithm, expert interviews and a workshop to select a set of priority sites. Habitats targeted included seagrasses, oyster reefs, sponge and soft coral, salt marshes, tidal fresh marshes and tidal flats. Sites are considered on a landscape scale, with entire bays and estuaries included in the plan (Beck et al., 2000).

The Essential Fish Habitat Amendments prepared by the Gulf of Mexico Fishery Management Council identify and describe Gulf habitats that are "required to support a sustainable fishery and the managed species' contribution to a healthy ecosystem" (NOAA, 1998). The document provides information for the identification and description of essential fish habitat for 26 representative species under federal management in the Gulf of Mexico. It also considers threats to essential fish habitat, identifies options for the conservation and enhancement of essential fish habitat and needed research to better identify and

describe essential fish habitat.

Gulf of Mexico Subregions

Although Gulf estuaries share many similar geographical features, habitat types, and habitat-dependent activities, the region has ecological differences. The Gulf of Mexico encompasses portions of both the Louisianan Province (Rio Grande, Texas, to Anclote Key, Fla.) and the West Indian Province (west coast of Florida from Tampa Bay to the Keys) and is greatly influenced by the Mississippi River. Gulf estuaries also vary geomorphologically, from complex networks of deltaic channels to shallow, bar-built systems. On the basis of these ecological and geographical distinctions, the region has been divided into four subregions.

The western, central and eastern Gulf subregions have been adopted based on The Nature Conservancy's ecoregional plan for the northern Gulf of Mexico (Beck et al., 2000). A southern subregion also has been added. For the purposes of this discussion, the Everglades, the Florida Keys and Florida Bay are excluded from the Gulf analysis and are discussed as part of the Southeast Atlantic regional analysis.

The following sections summarize the habitat issues and highlight certain restoration planning efforts for each of the four Gulf of Mexico subregions. Detailed information and additional plans are available through the National Strategy Restoration Plan Database (http://restoration.nos.noaa.gov).

Western Gulf of Mexico Subregion

Description

Extending from the southernmost coast of Texas to just south of Galveston Bay, the western subregion is characterized by low levels of freshwater inflow, sandy sediments, clear water and extensive growth of seagrasses. Estuaries in this subregion also support salt marshes, tidal flats, oyster reef, serpulid worm reefs, freshwater marshes, open bay, barrier islands and riparian woodlands.

Habitat Issues

Status and Trends

Within the subregion, direct loss of habitat has been attributed to erosion, damage by invasive species and other anthropogenic factors such as dredging and filling, hydrologic alteration and shoreline modification. Habitat also is being degraded as factors such as water and sediment quality affect the function of estuarine systems. For example, in the Coastal Bend, freshwater inflow has decreased by approximately 19 percent since 1940 (Coastal Bend Bays and Estuaries Program, 1998).

Threats

Degraded water and sediment quality as a result of point and nonpoint source pollution, and alteration of freshwater inflow have been identified as major concerns for the subregion. There also is concern that continued growth and changing land use within the subregion will have additional adverse effects, including fragmentation of habitat. Other threats to fishery species include increased fishing pressure, trawling and by-catch, and entrainment of organisms by industrial cooling systems.

Restoration Plans

Texas Coastal Management Plan (TCMP)

This plan was designed to meet the requirements for participation in the federal Coastal Zone Management Program and has been approved by NOAA. The TCMP coordinates state, local and federal programs for the management of Texas coastal resources. The plan is administered by the Coastal Coordination Council, which is charged with adopting uniform goals and policies to guide decision-making by all entities that regulate or manage natural resource use within the coastal area of Texas. Current areas of high priority are protecting wetlands, improving shoreline access, and addressing impacts of nonpoint sources of pollution.

To address priority issues, the Coastal Coordination Council oversees a TCMP grants program and a small business and individual permitting assistance program. Also under the TCMP, the Texas General Land Office leases coastal lands to the Texas Parks and Wildlife Department to manage as preserves. This Coastal Preserve program is designed to protect unique coastal areas and fragile biological communities. Two of the four currently designated preserves are in the western Gulf subregion: Welder Flats in San Antonio Bay and South Bay in the lower Laguna Madre.

Coastal Bend Bays Plan

The Coastal Bend Bays Estuary Program is implementing the Coastal Bend Bays Plan for the Aransas, Corpus Christi and upper Laguna Madre estuaries. The document outlines action plans for human uses, maritime commerce and dredging, habitat and living resources, water and sediment quality, freshwater resources and public education and outreach. Priority issues for the study area include freshwater inflow, condition of living resources, public health, loss of wetlands and other estuarine

habitats, degradation of water quality, altered circulation and debris.

Seagrass Conservation Plan for Texas
The Seagrass Conservation Plan for Texas is a cooperative effort of the Texas Parks and Wildlife Department, Texas General Land Office, Texas Natural Resource Conservation Commission, Galveston Bay Estuary Program, and Coastal Bend Bays Estuary Program. The document addresses the assessment, restoration and management of seagrasses in Texas waters.

The Clean Rivers Program
The Clean Rivers Program is administered by the Texas Natural Resource Conservation Commission, which works with river authorities and other stakeholders to address issues related to monitoring and assessment of water quality. The Texas General Land Office and the Texas Parks and Wildlife Department cooperate on the State-owned Wetlands Conservation Plan. The Texas Parks and Wildlife Department also implements the Texas Wetlands Plan.

Mission/Aransas Watershed Conservation Plan
The Texas General Land Office, in cooperation with EPA, has developed the Mission/Aransas Watershed Conservation Plan, which outlines habitat assessment, enhancement and education goals for portions of Aransas, Refugio and San Patricio counties. This local wetlands plan was designed as a model for other coastal communities interested in bringing stakeholders together to evaluate wetland issues and to develop a plan for conserving wetlands while allowing for economic growth.

Plan Elements

Goals
Restoration goals outlined in these documents focus on increasing and preserving the quality and diversity of habitats and living resources within the estuaries, enhancing water quality, and reducing debris. Reductions of point and nonpoint sources of pollution, creation of seagrass and marsh habitat, and maintenance of freshwater inflow have been identified as top priorities.

Methods
Several methods have been applied or recommended for achieving the subregion's restoration goals. Among these are creation of wetlands through the beneficial use of dredged material or by ponding, and enhancement of habitat and water quality via promotion of best management practices, participation in landowner initiatives, and development of a comprehensive regional water management plan.

Elements of Success
Common principles of successful estuarine restoration are apparent in the planning efforts for the western Gulf. Plans emphasize the need for cooperation of diverse entities, planning and restoration on an ecosystem level, and a high degree of public education and involvement in both the planning and implementation phases.

Information Needs
The understanding of habitat functions and the understanding of total loadings and transport pathways, as well as their biological effects, were identified as areas in need of further research. Long-term monitoring was suggested as an important tool for gathering this information.

Central Gulf of Mexico Subregion

Description
The central subregion includes Galveston Bay and spans the coasts of Louisiana, Mississippi and Alabama. The subregion is characterized by high, and sometimes variable, levels of freshwater inflow and by high levels of sediment input. The nutrient-rich waters and muddy sediments support extensive marsh and oyster reef habitat. Other key habitats within the subregion are freshwater marsh, oyster reef, seagrass, swamp, tidal flats, open bay, barrier islands, nesting islands, bayous, pitcher plant bogs, dune swales, forested wetlands, coastal prairie and long-leaf pine savannah.

Habitat Issues

Status and Trends
The marsh-dominated estuaries of the central Gulf have experienced tremendous habitat losses in recent decades. In Louisiana, more than 960,000 acres of marsh have been lost since 1930. Currently, an area of marsh the size of a football field is disappearing every 30 minutes (LCWCRT, 1998). In Galveston Bay, more than 30,000 acres of marsh and approximately 90 percent of the seagrass beds have been lost since the 1950s (Galveston Bay NEP, 1994). Alabama's fresh and salt marshes declined by 69 percent and 29 percent , respectively, between 1955 and 1979 (Alabama Department and Community Affairs, Science, Technology, and Energy Division, Coastal Programs Office, 1999). For these reasons, much of the restoration planning focuses on creating and enhancing marshes.

Threats
Habitat, residences, property and business opportunities are

being lost to subsidence and subsequent erosion. In addition to loss of habitat structure, most plans express concern about lost function caused by degraded water quality as a result of runoff and point sources of pollution, and changes in freshwater inflows. Habitat fragmentation has also been identified as a concern.

A variety of factors have been identified as contributing to habitat loss in the Central Gulf of Mexico subregion. Among these are subsidence, erosion and direct alterations, such as dredging and filling, changes to hydrology, shoreline modification, sand extraction, prop scarring, shoreline alteration and disturbance from trawling. Key among these is the loss of sediment and nutrients to Louisiana marshes, resulting in the levelling of the Mississippi River. Invasive species, particularly herbivores such as nutria, also are responsible for loss of habitat.

General habitat types including submerged aquatic vegetation, emergent vegetated wetlands, oyster reefs, shellfish beds and certain intertidal zones have been identified as areas of particular concern. Fisheries species most affected include brown shrimp, white shrimp, blue crab, oysters, red drum, black drum, speckled sea trout, gulf menhaden, southern flounder, largemouth bass and channel catfish. These habitats also support a variety of migratory neotropical birds, waterfowl, shore birds, wading birds and raptors, as well as threatened and endangered species such as the Florida yellow bat, American alligator, piping plover, Alabama red-bellied turtle, eastern indigo snake, black bear and gopher tortoise.

Restoration Plans

Texas Coastal Management Plan (TCMP)

The TCMP was designed to meet the requirements for participation in the federal Coastal Zone Management Program. The TCMP coordinates state, local, and federal programs for the management of Texas coastal resources. The plan is administered by the Coastal Coordination Council, which is charged with adopting uniform goals and policies to guide decision-making by all entities regulating or managing natural resource use within the Texas coastal area. Current areas of high priority are protecting wetlands, improving shoreline access and addressing impacts of nonpoint sources of pollution.

Weeks Bay National Estuarine Research Reserve

The Weeks Bay National Estuarine Research Reserve was established in Alabama in 1986 and currently encompasses 3,028 acres of protected estuarine lands and waters. The reserve management plan was approved by NOAA in 1998. Important habitats that may be useful for investigation and as reference sites include upland forests, fresh and saltwater marshes, forested swamps, pitcher plant bogs and tidal flats. Restoration priorities include restoring riparian buffers, shorelines, wetlands and bottom lands. Restoration projects currently underway include prior-converted wetland and riparian buffer restoration, pitcher plant bog restoration, salt marsh restoration and prescribed burning.

Galveston Bay Plan

The Galveston Bay Plan is undergoing its five-year review process. A five-year work plan is being generated that will include action items in the areas of habitat protection, species population protection, public health, freshwater inflow and bay circulation, spills and dumping, shoreline management, water and sediment quality, point and nonpoint sources of pollution, research, monitoring, and public participation and education. Restoration, creation and protection of wetlands are identified as top priorities for Galveston Bay.

The Galveston Bay Plan is administered by the Galveston Bay Estuary Program, a program of the Texas Natural Resource Conservation Commission, in conjunction with the Galveston Bay Council. The Council consists of representatives of state, federal and local natural resource agencies, the research community, local governments, citizens and other Galveston Bay stakeholders.

The Texas Coastal Management Plan and the Galveston Bay Plan are augmented by several state plans and programs. To address priority issues, the Coastal Coordination Council oversees a TCMP grants program and a small business and individual permitting assistance program. Also under the TCMP, the Texas General Land Office leases coastal lands to the Texas Parks and Wildlife Department to manage as preserves. This Coastal Preserve program is designed to protect unique coastal areas and fragile biological communities. Two of the four state-designated coastal preserves are in the Galveston Bay system: Armand Bayou and Christmas Bay.

Louisiana Coastal Resources Program

The Louisiana Coastal Resources Program is administered by the Louisiana Department of Natural Resources. The program works with local parishes to design programs that resolve conflicting local uses of the coast. Programs include the Coastal Use Permit Program and management of the Marsh Island Refuge and the Louisiana Offshore Oil Port.

Mississippi Coastal Program

The Mississippi Coastal Program is administered by the state Department of Marine Resources. An advisory council of citi-

zen and industry representatives makes recommendations to the program, and a commission of citizen and industry representatives creates the program's policies. The program manages port and beach special management areas based on separate management plans for those areas.

Grand Bay National Estuarine Research Reserve

The Grand Bay National Estuarine Research Reserve was established in Mississippi in 1999 and currently encompasses 18,000 acres of protected estuarine lands and waters. The reserve management plan was approved by NOAA in 1998. Important habitats that may be useful for investigation and as reference sites include wet pine savannah, coastal swamp habitats, estuarine tidal marsh and shallow water open bay. Restoration priorities include exotic species control, shoal and salt marsh restoration, oyster reef restoration, reestablishment of flood water flow and hydrological restoration, and prescribed burning in wet pine savannah and pine flatwoods. Current restoration projects include prescribed burning.

Alabama Coastal Area Management Plan

The Alabama Coastal Area Management Plan consists of comprehensive management policies and guidance for the protection and enhancement of the quality, quantity and viability of coastal resources and the management and uses of those resources. The plan was developed in response to the Coastal Zone Management Act and is used by the Alabama Coastal Area Management Program to balance preservation, conservation, enhancement and development of coastal resources while promoting a sustainable economy. The Alabama Coastal Area Management Program is a joint effort of the Alabama Department of Economic and Community Affairs, which has primary responsibility for planning and policy development, and the Alabama Department of Environmental Management, which has primary responsibility for regulation and implementation of policies and goals.

Barataria-Terrebonne Estuary Plan

The study area for the Barataria-Terrebone National Estuary Program includes the Barataria and Terrebonne basins and portions of the Mississippi and Atchafalaya rivers. The Barataria-Terrebonne Estuary Plan was developed in conjunction with the state of Louisiana, and is being implemented by the Barataria-Terrebone National Estuary Program and the Barataria-Terrebonne Management Council, which consists of state, federal and local resource agencies, as well as universities and diverse stakeholders. The plan identifies seven priority issues: hydrologic modifications, sediment reduction, habitat loss, eutrophication, pathogen contamination, toxic substances, and changes in living resources. The plan also contains action items in the areas of coordinated planning and implementation, ecological management, sustained recognition and citizen involvement, and economic growth.

Mobile Bay and Delta Comprehensive Conservation and Management Plan (Draft)

A draft Comprehensive Conservation and Management Plan is being finalized for Mobile Bay and Delta. The Mobile Bay National Estuary Program has outlined the issues and action items, which the plan will address in a document titled Our Water Our Future. The document was developed in coordination with a management conference, six community-based issue workgroups and a variety of research entities. Priority issues include water quality, physical and hydrologic modifications, habitat loss, living resources, human uses, and public education and involvement.

Habitat Conservation Blueprint

The Galveston Bay Foundation's Habitat Conservation Blueprint was developed with federal, state and local partners to facilitate the habitat restoration and protection goals of the Galveston Bay Plan. The Blueprint is an inventory of potential restoration sites within the Galveston Bay system, and includes information regarding potential strategies and resources. The Blueprint will be implemented by the Galveston Bay Foundation and other environmental organizations, resource agencies, universities, local governments, private landowners, industry representatives, and other stakeholders.

Action Plan for Reducing, Mitigating, and Controlling Hypoxia in the Northern Gulf of Mexico

Another example of an interagency water quality improvement effort that can be used to forward restoration activities is the Action Plan for Reducing, Mitigating and Controlling Hypoxia in the Northern Gulf of Mexico. Federal agencies have joined together in response to a serious threat that has been linked to nutrient over-enrichment. Each summer in the Gulf of Mexico, the oxygen levels near the bottom become too low to allow most fish and crustaceans to live, resulting in an 8,000 square mile “dead zone.” Concern about the dead zone is both environmental and economic as approximately 40 percent of U.S. fisheries landings come from this area. Research indicates that the dead zone is caused by a combination of natural and human influences, with the main driver being excess nutrients. Nitrogen loads in the Mississippi Basin come from a variety of sources, but over half can be attributed to agriculture, primarily runoff of nitrate from fertilizers.

To address this issue, federal agencies along with other stakeholders have crafted an Action Plan for Reducing, Mitigating,

and Controlling Hypoxia in the Northern Gulf of Mexico. The Action Plan describes a national strategy to reduce the frequency, duration, size and degree of oxygen depletion of the hypoxic zone of the northern Gulf of Mexico. The plan is the result of several years of study and discussion by the members of the Mississippi River/Gulf of Mexico Watershed Nutrient Task Force and many concerned officials and citizens who participated in their deliberations. The primary approaches to reduce hypoxia in the Gulf of Mexico outlined are to reduce nitrogen loads from watersheds to streams and rivers in the basin and restore and enhance denitrification and nitrogen retention within the basin. While the primary focus of this strategy is reducing nitrogen loads to the northern Gulf, many of the actions proposed in this plan also will achieve basin-wide improvements in surface-water quality by reducing phosphorous. Likewise, actions taken to address local water quality problems in the basin often contribute to reductions in nitrogen loadings to the Gulf.

Coast 2050: Toward a Sustainable Coastal Louisiana
Perhaps the most all-encompassing restoration plan within the Gulf region is Louisiana's Coast 2050: Toward a Sustainable Coastal Louisiana. This strategic plan for the survival of Louisiana's coast and communities promotes restoration and protection on a coast-wide basis, and recommends strategies that work with natural forces such as the river, climate, and tidal influences. The strategies included in the plan are expected to prevent the loss of 1,000 square miles of coastal habitat.

Coast 2050, which has been approved by all 20 of Louisiana's coastal parishes, involved federal, state and local entities, landowners, environmentalists, scientists and other stakeholders. Partners include the Louisiana Coastal Wetlands Conservation and Restoration Task Force (U.S. Army Corps of Engineers, National Marine Fisheries Service [NMFS], USFWS, Natural Resources Conservation Service [NRCS], EPA, and the Office of the Governor of Louisiana) and the Louisiana State Wetlands Conservation and Restoration Authority (Office of the Governor of Louisiana; the Louisiana Departments of Natural Resources, Transportation and Development, Environmental Quality, and Wildlife and Fisheries; Louisiana Division of Administration; and State Soil and Water Conservation Committee.)

Louisiana Coastal Wetlands Restoration Plan and the Coastal Wetlands Conservation and Restoration Plan
Coast 2050 builds on previous restoration planning efforts for the Louisiana coast, including the Louisiana Coastal Wetlands Restoration Plan and the Coastal Wetlands Conservation and Restoration Plan. Coast 2050 also builds on the projects and partnerships developed under the Coastal Wetlands Planning, Protection and Restoration Act of 1990 (CWPPRA). CWPPRA established a multi-agency task force that is responsible for program management and project selection based on recommendations of the technical committee. The task force is comprised of NOAA Fisheries, Army Corps of Engineers, the U.S. Fish and Wildlife Service, the Environmental Protection Agency, the Natural Resources Conservation Service and the Louisiana Governor's Office.

Since 1991, 99 CWPPRA projects have been authorized in Louisiana's nine coastal basins. The projects are expected to create, protect and restore 75,000 acres of wetlands over the next 20 years. Demonstration projects and feasibility studies are also part of CWPPRA. CWPPRA funds enabled a comprehensive approach to restoration by funding restoration, coordinated planning and monitoring.

Citizens' groups such as the Coalition to Restore Coastal Louisiana, the Lake Pontchartrain Basin Foundation, the Acadiana Bay Association and the Vermillion Rice Growers Association have played a significant role in habitat restoration planning for Louisiana.

Plan Elements

Goals
Habitat goals for the central Gulf focus on the restoration of productivity and diversity through the enhancement of habitat structure and function. Examples of restoration goals for the area include Galveston Bay's target of restoring and/or conserving 24,000 acres of habitat by 2010, and Coast 2050's overarching goal to “sustain a coastal ecosystem that supports and protects the environment, economy and culture of southern Louisiana, and that contributes greatly to the economy and well-being of the nation.”

Many closely linked goals call for the protection, enhancement or creation of lost habitats such as marshes, seagrasses, coastal prairies, swamps, bay and lake shorelines, barrier islands and critical land forms. Other goals address the causes of habitat loss and degradation. These goals are designed to control invasive species, ensure freshwater and sediment inflows, improve water quality and restore riparian buffer zones and barrier islands. Still other goals focus on the restoration of goods and services provided by estuarine habitats. In order to achieve one set of goals—the restoration of goods and services provided by estuarine habitats—actions aim to preserve and enhance fisheries resources, such as maintenance of temporal and spatial biodiversity; maintenance of exchange and interface to achieve

system linkages; and reduction of water and sediment toxicity. Restoration of colonial bird nesting habitat, elimination of dumping and debris, and control of shoreline erosion also are examples of goals based on the recovery of habitat services.

Methods

Within the central Gulf subregion, a variety of restoration methods have been suggested, developed and applied. Although specific strategies are linked to particular habitats and threats, most habitats can benefit from landowner initiatives, removal of debris, establishment of habitat corridors and land use planning.

Erosion control and compensation methods include nonstructural shoreline stabilization, brush fences and breakwaters, artificial reefs, shoreline scraping and grading, and rebuilding coastal ridges. Where subsidence has occurred or sedimentation patterns have been altered, techniques such as terracing, the beneficial use of dredged material, dedicated dredging for wetland creation, induced deposition of sediment, and sediment diversion are recommended.

The innovative marsh terracing project at Sabine National Wildlife Refuge has served as a model for smaller projects in Galveston Bay. Louisiana also is pioneering the large-scale use of freshwater diversion as part of the Caernarvan and Davis Pond restoration projects. As part of its plan to deepen and widen the Houston Ship Channel, the Port of Houston Authority has consulted with resource agencies to create marsh, nesting areas and oyster reef habitats.

Seagrasses have been transplanted using a variety of methods, and there is interest in developing nursery capability. Methods for revegetation include the use of either nursery or transplant stock. Techniques for enhancing oyster reefs also are being developed, mostly with use of supplemental culch or artificial substrate. Coastal prairie is often managed through the use of prescribed burns and the removal of invasive species.

Restoration of hydrologic conditions is often necessary and can encompass, the diversion of freshwater, management of pump outfalls and removal of pipelines. To address water quality issues, many plans suggest the creation of buffer zones, reduction of septic tank and sewer overflows, implementation of best management practices and improvement of unpaved roads.

Elements of Success

Several common themes have been identified among the central Gulf plans. Of the documents reviewed, nearly all recommended the development of strong partnerships, involvement of diverse stakeholders, and facilitation of coast-wide cooperation. The integration of research and the acquisition, interpretation and application of information were also emphasized, along with the use of predictive modeling. There seems to be a consensus that restoration should be planned and implemented at the watershed or ecosystem level. Also recommended is an increase in public support within the context of communities and a tenfold increase in current funding levels.

Information Needs

Interdisciplinary research is recommended to:

- Identify rare and threatened habitats;
- Improve understanding of structure and function of coastal habitats;
- Improve understanding of human impacts on habitat;
- Improve understanding of water and sediment processes and interactions;
- Develop innovative, practical techniques for habitat enhancement, especially the design of structures and methods for managing hydrology, and the development of techniques and materials for marsh creation;
- Employ hydrologic studies to determine restoration needs and strategies;
- Develop a regional monitoring program; and
- Assess current status and trends.

Eastern Gulf of Mexico Subregion

Description

The upper Gulf Coast of Florida, south to Anclote Key, defines the eastern subregion. Moderate freshwater inflow, coarser sediments and clearer water than is found in the central subregion supports extensive seagrass habitat. Where the limestone bottom is exposed, sponge and soft coral communities exist. In addition, the subregion also supports salt marsh, freshwater marsh, oyster reef, open water, barrier islands, bayous, dune lakes, forested wetlands, sand pine, pine flatwoods, scrub hammock and hardwood hammock.

Habitat Issues

Status and Trends

There is some indication that fisheries have been declining in Pensacola Bay (Northwest Florida Water Management District, 1997). Throughout the subregion, fishery species such as blue crab, shrimp, oysters and bay scallops, as well as finfish such as redfish, flounder, mullet, menhaden, speckled sea trout and largemouth bass, are identified as key beneficiaries of habitat restoration. Protected species of particular concern in the East-

ern Gulf region include pelicans, plovers, oyster catchers, skimmers, terns, raptors, alligators and river otters.

Threats

Within the eastern Gulf, habitat is being lost, degraded, fragmented and threatened. Hydrologic alterations, invasive species, dredging and filling have caused much of the habitat loss within this subregion. Changing land uses, an increase in the amount of polluted runoff, point and nonpoint sources of pollution, changes in freshwater inflow, and withdrawal of groundwater threaten estuarine habitats in the subregion.

Restoration Plans

Florida Coastal Management Program

The Florida Coastal Management Program activities relate to the protection, preservation and development of Florida's natural, cultural and economic coastal resources. A network of 10 agencies implements the program, led by the Florida Department of Community Affairs. A 15-member Governor's Coastal Advisory Committee advises the governor and the legislature on coastal management issues and program implementation. The Coastal Management Program implements 23 state statutes related to coastal resources.

Management Plan for the Apalachicola National Estuarine Research Reserve

The Apalachicola National Estuarine Research Reserve was established in Florida in 1979 and currently encompasses 246,766 acres of protected estuarine lands and waters. The reserve management plan was approved by NOAA in 1998. Important habitats that may be useful for investigation and as reference sites include forested flood plains, fresh- and saltwater marshes, oyster bars and barrier islands. Restoration priorities include restoring historic hydrology, historic biological communities and fire regimes. Current restoration projects include shoreline stabilization, Phragmites removal, marsh restoration and prescribed burning.

Surface Water Improvement and Management Plans

The Northwest Florida Water Management District has prepared Surface Water Improvement and Management Plans for Pensacola Bay, St. Marks River and the Choctawatchee River and Bay systems. These plans for comprehensive coordinated watershed management describe the resources and issues of the watershed, as well as the resource management activities of various resource agencies. The plans also describe proposed projects to address issues related to watershed management, biological concerns, water quality and public awareness.

Plan Elements

Goals

Restoration goals focus on the protection and restoration of seagrasses, marshes and forests, and on the reduction of runoff and point source pollution. Maintenance of historic freshwater inflow and the protection of listed species also are priorities for the eastern Gulf.

Methods

Shellfish restoration methods have involved enhancement of oyster reefs, construction of artificial reefs and the transplanting of scallop. Improvements to stormwater and wastewater management and treatment, landowner initiatives and implementation of best management practices for urban and agricultural areas have been identified as techniques for improving water quality. Seagrass planting and sediment detention have been recommended for restoration of vegetated habitat.

Elements of Success

Consistent with other Gulf subregions, key elements for successful restoration are: system-wide coordination, public education and involvement, and incorporation of research.

Information Needs

Two research priorities—mapping of existing natural resources and long-term monitoring of existing and restored habitat—have been developed for the subregion.

Southern Gulf of Mexico Subregion

Description

The southern subregion encompasses the Gulf Coast of Florida from south of Anclote Key to Cape Romano. The region is characteristic of the West Indian ecological province. In addition to salt marsh and seagrass, the clear, shallow estuaries of the southern Gulf also support extensive mangrove habitat. Other key habitats are oyster reef, freshwater marsh, barrier islands, swamp, salt pans, dry-zone scrub, pine flatwoods, oak scrub, scrub flatwoods and hammocks.

Habitat Issues

Status and Trends

Direct loss of habitat has occurred as a result of erosion, degraded water quality, and physical disturbance. Since 1870, approximately 80 percent of the seagrasses and 50 percent of the salt marsh and mangrove habitat in Tampa Bay have been lost (Tampa BayWatch, 1998). Erosion and degraded water

quality affect estuaries as a whole, as do changes to freshwater inflow and changing land use. Invasive species and hydrologic alteration are particularly damaging to marshes, and prop scarring is a large problem in seagrass beds. In some cases, public overuse and misuse of natural areas also are leading to degradation.

Threats

Plans emphasize the effects of habitat loss on fisheries species such as mullet, blue crab, and stone crab. Several protected species inhabit the southern Gulf subregion, including: West Indian manatee, Atlantic loggerhead turtle, gopher tortoise, indigo snake, Florida panther and 16 species of threatened or endangered birds. These species are threatened by a variety of habitat alterations. There also is a concern that habitat is becoming fragmented and migration corridors are being severed.

Restoration Plans

Florida Coastal Management Program (see Restoration Plans for the Eastern Gulf of Mexico Subregion).

Charlotte Harbor Comprehensive Conservation and Management Plan (Draft)

The Charlotte Harbor National Estuary Program has completed a draft Comprehensive Conservation and Management Plan for the greater Charlotte Harbor watershed, including the Caloosahatchee River and Estero Bay watersheds, Lower Peace and Myakka River watersheds, and the Upper Peace and Myakka River watersheds. The plan identifies hydrologic alterations, water quality degradation, and fish and wildlife habitat loss as priority issues.

Charting the Course, the Comprehensive Conservation and Management Plan for Tampa Bay

Charting the Course was produced by the Tampa Bay National Estuary Program in cooperation with local government and agency partners. The document addresses seven priority issues: degradation of water quality; impacts to living resources and habitats; impacts associated with human uses of the estuary; agency coordination and response; community awareness; bay circulation and flushing; and spills and contamination. Restoration and protection of seagrasses is a key goal. The goal is to restore 12,350 acres and protect the Tampa Bay's existing 25,600 acres of grass beds based on restoring the vital underwater seagrass meadows to 1950s levels. This will largely be achieved by controlling the bay's nitrogen loading, although other factors such as turbidity and water color, also influence seagrass regrowth. The goal includes restoring at least 100 acres of low-salinity tidal stream habitat every five years for a total increase over time of 1,800 acres, while preserving existing salt marshes and mangroves.

Management Plan for the Rookery Bay National Estuarine Research Reserve

The Rookery Bay National Estuarine Research Reserve was established in Florida in 1978 and currently encompasses 9,400 acres of protected estuarine lands and waters. The reserve management plan was approved by NOAA in 1998 and is currently being revised. Important habitats that may be useful for investigation and as reference sites include tropical hardwood hammocks, xeric scrub, pine flatwoods, saltwater marsh, mangroves, shallow bay waters and barrier islands. Restoration priorities include hydrologic restoration and native community restoration. Current restoration projects include hydrological restoration through roadbed removal and GeoWeb installation, invasive plant control, mangrove restoration and prescribed burning.

Southwest Florida Conservation Corridor Tampa Bay Watershed

This framework document is designed to provide a partnership vehicle to synchronize comprehensive planning efforts by a host of independent partners. Designed to be a "living document," it will provide a template for developing strategies and priorities through time and allow for new opportunities for federal, state and regional governments to work together with local governments and the private sector to explore and develop innovative conservation, restoration and preservation programs. Further, it will allow funding requests to be streamlined as monies become available for acquisition and restoration at the local, state and federal levels. Under the guidance of the Agency on Bay Management (ABM), this document is the result of a unified planning effort with state and federal agencies, local governments, private landowners, and nongovernmental organizations and businesses (Southwest Florida Conservation Corridor planning document, 2001).

Land Management Plan for the Estero Bay State Buffer Preserve

The Land Management Plan for the Estero Bay State Buffer Preserve has been prepared by the Bureau of Coastal and Aquatic Managed Areas in the Florida Department of Environmental Protection's Division of Marine Resources. The document describes the resources associated with the preserve, as well as proposed management activities and the roles of managing agencies, the public and local government in management of the area. The plan identifies the following restoration goals: assess natural resources and restoration needs, establish

and post presence boundaries, manage invasive plant species, manage ecosystems with prescribed burns, and control damage by feral hogs.

Tampa BayWatch and other citizens' groups have been very active in the implementation of community-based restoration projects. Tampa BayWatch has published the results of several workshops that identify restoration sites and resources, as well as proposed project selection criteria. The Tampa Surface Water Improvement and Management Department has also prepared a five-year plan that includes potential restoration sites.

Plan Elements

Goals

Restoration goals focus on enhancing hydrology, water quality, and habitats such as seagrass, salt marsh, oyster reefs, freshwater marsh, native uplands and mud flats. Ecological function will be restored through establishment of buffer zones around sensitive areas and restoration of freshwater inflow. Also planned are activities that will control invasive species populations and assist with the recovery of protected species populations.

Methods

For preserve areas, techniques as simple as posting boundaries have been identified. Prescribed burns and removal of trash and invasive species have been recommended for marshes and uplands. The conservation of flyways has also been identified as essential.

Elements of Success

Restoration planners in the southern Gulf subregion have shown strong support for public education and involvement; cooperation of federal, state and local agencies with other organizations; science-based adaptive management; coordination of regional maps and databases; and partnerships among universities, resource agencies and research institutions. Also noted as an essential element of successful restoration was the ability to balance human use and sensitive areas.

Information Needs

Several types of information were determined to be necessary for successful restoration in the subregion, including:

- assessment of management strategies for listed species;
- effectiveness of control techniques for invasive species;
- freshwater inflow needs;
- existing resources (inventory and status of existing resources);
- the carrying capacity of sensitive habitats relative to public use and mosquito control methods; and
- GIS-based information about habitat distribution, topography, hydrology, and biological and cultural resources.

References

Alabama Department of Economic and Community Affairs, Science, Technology, and Energy Division, Coastal Programs Office. 1999. *Alabama Coastal Area Management Plan, Program Document III.*

Auburn University Marine Extension Program. 2000. Draft: *Dog River Watershed Management Plan.*

Barataria-Terrebonne National Estuary Program. 1995. Saving Our Good Earth: A Call to Action. Barataria-Terrebonne National Estuary Program Characterization Report.

Barataria-Terrebonne National Estuary Program. 1996. *Comprehensive Conservation and Management Plan, Part I. The Executive Summary*. Program Objectives, Action Plans, and Implementation Strategies at a Glance.

Barataria-Terrebonne National Estuary Program. 1996. *Comprehensive Conservation and Management Plan, Part II. The Estuary Compact.* A Public Private Promise to Work Together to Save the Barataria-Terrebonne Basins.

Beck, M, W.M. Odaya, J.J. Bachant, B. Keller, R. Martin, R. Mathews, C. Porter, G. Ramseur. 2000. *Identification of Priority Sites for Conservation in the Northern Gulf of Mexico: An Ecoregional Plan.* The Nature Conservancy, Arlington, Va.

Boesch, D., M. Josselyn, A. Hehta, J. Morris, W. Nuttle, C. Simenstead, D. Smith. *Scientific Assessment of Coastal Wetland Loss, Restoration, and Management in Louisiana. Executive Summary.*

Center for Coastal Studies, Texas A&M University at Corpus Christi. 1999. *Mission/Aransas Watershed Conservation Plan.*

Charlotte Harbor National Estuary Program. 1999. Committing to Our Future, Volume I. *A Draft Comprehensive Conservation and Management Plan for the Greater Charlotte Harbor Watershed.*

Charlotte Harbor National Estuary Program. 1999. *Committing to Our Future, Volume II. Preliminary Action Plan for the Greater Charlotte Harbor Watershed.*

City of St. Petersburg Planning Department. 1994. City of St. Petersburg Environmental Enhancement Program. *Five-Year Plan 1995-2000.*

Coalition to Restore Coastal Louisiana. 1989. *Here Today and Gone Tomorrow? A Citizen's Program for Saving the Mississippi River Delta Region to Protect its Heritage, Economy, and Environment.*

Coastal Bend Bays and Estuaries Program. 1998. *Coastal Bend Bays Plan.*

Coalition to Restore Coastal Louisiana. 1997. Course Correction. *Developing a Sustainable Vision for the Mississippi River Corridor.* Main Report.

Dahl, T.E. 1990. Wetlands Losses in the United States 1780s to 1980s. U.S. Department of the Interior, Fish and Wildlife Service, Washington, D.C.

Duke, T. and W. Kruczynski. 1992. Status and Trends of Emergent and Submerged Vegetated Habitats, Gulf of Mexico, U.S.A. U.S. Environmental Protection Agency, Office of Water, Gulf of Mexico Program, Stennis Space Center, Miss. 161 pages.

Edgar, Graham J., N. Barrett, D. Graddon, and P. Last. 1999. The conservation significance of estuaries: a classification of Tasmanian estuaries using ecological, physical and demographic attributes as a case study. Biological Conservation 92. 383-397.

Erwin, Kevin L. 1996. Bibliography of Wetland Creation and Restoration Literature. Association of State Wetland Managers.

Florida Department of Environmental Protection. 1998. *Apalachicola National Estuarine Research Reserve Management Plan 1998-2003.*

Florida Department of Environmental Protection, Division of Marine Resources, Bureau of Coastal and Aquatic Managed Areas. 1997. *Land Management Plan for the Estero Bay State Buffer Preserve, Lee County Florida for the period May 1997 through May 2002.*

Florida Department of Environmental Protection, Office of Coastal and Aquatic Managed Areas. 2000. *Rookery Bay National Estuary Research Reserve Management Plan 2000-2005.*

Florida Ecotourism/Heritage Tourism Advisory Committee. 1997. *Recommendations on the Statewide Plan to Protect and Promote the Natural, Coastal, Historical, Cultural and Commercial Assets of Florida.* Planning for the Florida of the Future.

Florida Sea Grant. 1993. *Florida's Estuaries: A Citizen's Guide to Coastal Living and Conservation.*

Fonseca, M. A *Guide to Planting Seagrasses in the Gulf of Mexico.*

Fonseca, Mark S. 1992. Restoring Seagrass System in the United States. Chapter 3 in *Restoring the Nation's Marine Environment,* G. Thayer, ed. Maryland Sea Grant College.

Fonseca, M., W. Kenworthy, and G. Thayer. 1998. Guidelines for the Conservation and Restoration of Seagrasses in the United States and Adjacent Waters. NOAA's Coastal Ocean Program. Decision Analysis Series No. 12.

Freyer, W.E., T. Monahan, D. Bowden, and F. Graybill. 1983. Status and trends of wetlands and deep water habitats in the coterminous United States, 1950s to 1970s. Colorado State University, Department of Forest and Wood Sciences, Fort Collins. 32 pages.

Galveston Bay Estuary Program. 2001. Ebb & Flow. Galveston Bay Characterization Highlights.

Galveston Bay Estuary Program. 2001. State of the Bay Symposium V.

Galveston Bay Estuary Program. 1994. The State of the Bay. A Characterization of the Galveston Bay Ecosystem.

Galveston Bay Foundation. 1998. *Habitat Conservation Blueprint.* A Plan to Save the Habitats and Heritage of Galveston Bay.

Galveston Bay National Estuary Program (NEP). 1994. *The Galveston Bay Plan.* The Comprehensive Conservation and Management Plan for the Galveston Bay Ecosystem.

Handley, L.R. 1995. Seagrass Distribution in the Northern Gulf of Mexico. U.S. Environmental Protection Agency, Office of Water, Gulf of Mexico Program, Stennis Space Center, Miss. 161 pages.

Houston-Galveston Area Council. 2000. *Seabrook Wetlands Conservation Plan.*

Louisiana Coastal Wetlands Conservation and Restoration Task Force (LCWCRT). 1993. *Louisiana Coastal Wetlands Restoration Plan.* Main Report and Environmental Impact Statement.

Louisiana Coastal Wetlands Conservation and Restoration Task Force (LCWCRT). 1997. Evaluation Report to the U.S. Congress on the Effectiveness of Louisiana Coastal Wetland Restoration Projects.

Louisiana Coastal Wetlands Conservation and Restoration Task Force (LCWCRT) and the Wetlands Conservation Authority. 1998. *Coast 2050: Toward a Sustainable Coastal Louisiana.*

Louisiana Coastal Wetlands Conservation and Restoration Task Force (LCWCRT) and the Wetlands Conservation Authority. 1998. *Coast 2050: Toward a Sustainable Coastal Louisiana.* The Appendices.

Martin, D., T. Morton, T. Dobrzynski, and B. Valentine. 1996. *Estuaries on the Edge: The Vital Link Between Land and Sea.* American Oceans Campaign.

Matthews, G., and T. Minello, eds. 1994. Technology and Success in Restoration, Creation, and Enhancement of *Spartina alterniflora* Marshes in the United States. Volume I. Executive Summary and Annotated Bibliography.

Matthews, G., and T. Minello, eds. 1994. Technology and Success in Restoration, Creation, and Enhancement of *Spartina alterniflora* Marshes in the United States. Volume II. Inventory and Human Resources Directory. NOAA's Coastal Ocean Program. Decision Analysis Series No. 2.

Mississippi Department of Environmental Quality, Water Quality Assessment Branch. 2001. *Managing Our Waters…Basin by Basin.*

Mississippi Department of Environmental Quality, Water Quality Assessment Branch. 2001. *Managing Our Waters…From the Land.*

Mississippi Department of Environmental Quality, Water Quality Assessment Branch. 2001. *Managing Our Waters…With Local Government.*

Mississippi River/Gulf of Mexico Watershed Nutrient Task Force. 2001. *Action Plan for Reducing, Mitigating, and Controlling Hypoxia in the Northern Gulf of Mexico.*

Mobile Bay National Estuary Program. 1999. Our Water, Our Future. Mobile Bay and Delta.

Moulton, D., and J. Jacob. 2000. *Texas Wetlands Guidebook.*

National Estuarine Research Reserve System. 1998. *Weeks Bay National Estuarine Research Reserve Management Plan.*

National Marine Fisheries Service. 2000. Fisheries of the United States – 1999. Silver Spring, Md. National Marine Fisheries Service, Office of Science and Technology, Fisheries Statistics and Economics Division.

National Oceanic and Atmospheric Administration (NOAA). National Ocean Service. 1990. Estuaries of the United States. Vital Statistics of a National Resource Base. A Special NOAA 20th Anniversary Report.

National Oceanic and Atmospheric Administration (NOAA) /Gulf of Mexico Fishery Management Council. *Generic Amendment for Addressing Essential Fish Habitat Requirements in the Fishery Management Plans of the Gulf of Mexico: Gulf of Mexico Fishery Management Council.* 1998.

Neckles, H.A., ed. 1993. Seagrass Monitoring and Research in the Gulf of Mexico: Draft Report of a Workshop Held at Mote Marine Laboratory in Sarasota, Fla., January 28-29, 1992. National Biological Survey, National Wetlands Research Center, Lafayette, La. 75 pages.

Northwest Florida Water Management District. 1997. *Pensacola Bay System Surface Water Improvement and Management Plan.*

Pashley, D., C. Beardmore, J. Fitzgerald, R. Ford, W. Hunter, M. Morrison, and K. Rosenberg. 2000. *Partners in Flight. Conservation of the Land Birds of the United States.* American Bird Conservancy.

Sheehy, D.J. and S.F. Vik. 1992 Developing Prefabricated Reefs: An Ecological and Engineering Approach. Chapter 12 in *Restoring the Nation's Marine Environment,* G. Thayer, ed. Maryland Sea Grant College.

Tampa Bay National Estuary Program. 1996. *Charting the Course for Tampa Bay. The Comprehensive Conservation and Management Plan for Tampa Bay.*

Tampa Bay National Estuary Program. 1996. *Setting Priorities for Tampa Bay Habitat Protection and Restoration: Restoring the Balance.*

Tampa BayWatch, Inc., 1998. High School Saltmarsh Wetland Nursery Program. Operations Manual.

Tampa BayWatch, Inc. 2000. *Beneficial Use of Dredge Material for Tampa Bay Bottom Habitat Restoration.*

Tampa BayWatch, Inc. 1998. *A Conservation Blueprint for Habitat Restoration in Tampa Bay.* Prioritizing habitat restoration sites and funding opportunities to restore coastal ecosystems in the Tampa Bay estuary.

Tampa BayWatch, Inc. 1998. *Prioritizing Habitat Restoration Sites in the Tampa Bay Region.* Workshop Summary.

Tampa SWIM Department. 1996. SWIM Potential Restoration Sites. *Five Year Plan FY 95-FY 2000.*

Texas General Land Office. 1996. *Texas Coastal Wetlands. A Handbook for Local Governments.*

Texas Natural Resource Conservation Commission. 1998. State of the Texas Environment, Volume II. *Strategic Plan for Fiscal Years 1999-2003.*

Texas Parks and Wildlife Department. 1999. *Seagrass Conservation Plan for Texas.*

Texas Parks and Wildlife Department. 1995. Wetlands Assistance Guide for Landowners.

Thayer, Gordon, ed. 1992. Restoring the Nation's Marine Environment. Maryland Sea Grant College.

Turner, R.E. 1977. Intertidal vegetation and commercial yields of penaeid shrimp. Transactions of the American Fisheries Society, Kissimmee, Fla. 543 pages.

Turner, R.E. and D.F. Boesch. 1988. Aquatic Animal Production and Wetland Relationships: Insights Gleaned Following Wetland Loss or Gain. In The Ecology and Management of Wetlands. Vol I. Ecology of Wetlands. Timber Press: Portland, Ore. pp. 25-39.

U.S. Army Corps of Engineers. 1996. *Planning and Evaluating Restoration of Aquatic Habitat from an Ecological Perspective.*

U.S. Environmental Protection Agency. 1999. Ecological Condition of Estuaries in the Gulf of Mexico. EPA 620-R-98-004. U.S. Environmental Protection Agency, Office of Research and Development, National Health and Environmental Effects Research Laboratory, Gulf Ecology Division, Gulf Breeze, Fla.

U.S. Fish & Wildlife Service. 1998. Final Habitat Stewardship Program. Texas Chenier Plain.

Wetlands Conservation and Restoration Authority. 2000. *Coastal Wetlands Conservation and Restoration Plan.* Fiscal Year 2000-2001.

White, W., T. Calnan, and R. Morton. 1998. Evaluation of Marsh Creation and Restoration Projects and Their Potential for Large-Scale Application, Galveston-Trinity Bay System

Willard, J.D., and H. Hull, eds. 1995. *Wetlands and Watershed Management: Science Applications and Public Policy.* Association of the State Wetland Managers Institute for Wetland Science and Public Policy.

World Wildlife Fund. 1992. *Statewide Wetland Strategies. A Guide to Protecting and Managing the Resource.*

Yozzo, D. and J. Titre, eds. 1997. Coastal Wetland Restoration Bibliography. U.S. Army Corps of Engineers Wetlands Research Program Technical Report WRP-RE-20.